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DESIGN OF A COMBINATION OF COMPOST PLANT AND LANDFILL FOR MUNICIPAL SOLID WASTE MANAGEMENT OF GUWAHATI CITY

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ABSTRACT

With the increase in population and rapid socio-economic development, a tremendous increase in the municipal solid waste (MSW) is observed. It has become a pressing issue in India because there are only a few proper disposal systems for the MSW in many Indian cities. Therefore suitable disposal of these wastes is a big concern in the present time. In this paper the treatment and disposal of the MSW of Guwahati city is planned. The population of Guwahati city is estimated for the year of 2025 by arithmetic mean method and then the waste generation is calculated from it. From the data, a compost plant is designed for treatment of the city MSW and a landfill is also designed to dump the remaining waste after composting. For 2015, the total quantity of MSW is calculated as 781.79 tons/day, and the average generation rate of MSW has been calculated as 0.74 kg/capita/day taking waste generation growth rate as 1.41 percent per annum as given by World Bank. For composting, required numbers of aerobic windrows are found as 60 and for landfill, which is designed with cover and liner, plan dimensions found as 241 m × 482 m with extra 25 m land around the landfill to set infrastructure amenities.

KEYWORDS: Municipal Solid Waste, Compost Plant, Windrow, Landfill, Liner, Design

INTRODUCTION

Although the rapid urbanization has led the developmental arena, yet the cost related to it is also very high. One example of this is the increase in municipal solid waste generation. With increase in solid waste, the disposal of it becomes an issue of growing concern. In the present scenario of waste management system in Indian cities, there is acute scarcity of a suitable solid waste treatment and disposal system. Guwahati is a metropolitan city of India located at 26.18° N latitude and 91.73° E longitude with an area of 216 square km and a population of 963,416 for the year 2011(office of the Commissioner, GMC, 2014). Guwahati, once very pristine is today littered with filth and garbage due to lack of proper treatment and disposal of municipal solid waste. Although the Guwahati municipal corporation is trying its best for the appropriate solid waste disposal of the city still there are many spaces for the improvement of the system with the help of proper technology and expertise. A well designed solid waste management system can help not only in treating and discarding the waste but also in maintaining a better environment. Landfilling is the final discarding practice for Municipal Solid Wastes (MSW) management (CPCB, 2008). Due to pretreatment there is a transform in the composition and properties of the waste which will influence the degradation and settlement characteristics of wastes (Siddiqui et al., (2012). If the MSW is first composted and the residual waste after composting is discarded in a sound designed sanitary landfill then the trouble of appalling environmental risk due to MSW can be treated with an excellent mode.

OBJECT IVES

For the pretreatment and disposal of municipal solid waste, a combination of compost plant and sanitary landfill is designed so that a healthier and sustainable environment continues. This study aims to fulfill the following objectives

- Calculation of the total solid waste generated for the Guwahati city. The total waste generation is Premeditated for a period of 10 years span from 2015 to 2025.
- Design of a compost plan.
- Design of a sanitary landfill.

RESULTS AND DISCUSSIONS

Arithmetic increase method is used calculate the population of Guwahati city and from the population, waste generation is calculated. The rate of waste generation is estimated to grow at an exponential rate of 1.41 per cent per annum by the World Bank's Urban Development Section (East Asia and Pacific Region) (Verma, 2010).

Table 1: Calculation of Population and Waste Generation

Year	Population	Waste Generation Rate (Kg/Capita/Day)	Total Waste Generation (Tons/Day)
2015	1056012	0.7403	781.78
2016	1079161	0.7508	810.19
2017	1102310	0.7613	839.24
2018	1125459	0.7721	868.95
2019	1148608	0.7830	899.32
2020	1171757	0.7940	930.39
2021	1194906	0.8052	962.14
2022	1218055	0.8166	994.61
2023	1241204	0.8281	1027.80
2024	1264353	0.8397	1061.74
2025	1287502	0.8516	1096.42

Ultimate Analysis

Kaushik et al., 2012 gives the physical characteristics of Guwahati municipal solid waste. From those physical characteristics the ultimate analysis of the MSW on dry basis is prepared.

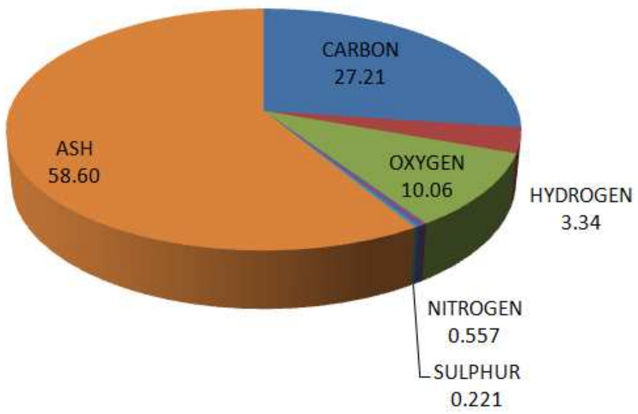

Figure 1: Ultimate Analysis of MSW (Dry Basis) of Guwahati City

Designs for Compost Plant

Air Required for Aerobic Composting

From ultimate analysis the formula for the Guwahati waste is $C_{329.1}H_{448.8}O_{91.27}N_{5.774}S$

Theoretical air required for aerobic composting is calculated by the formula (1) and (2)

$$C_aH_bO_cN_d + [(4a+b-2c-3d)/4]\ O_2 = aCO2 + [(b-3d)/2]\ H_2O + dNH_3 \quad (1)$$

Oxidation of NH3:

$$NH_3 + 2O_2 = H_2O + HNO_3 \quad (2)$$

Theoretical total air required = 9.21 ton of air/ton of organic matter

Actual air to be supplied = 2 × Theoretical air

= 18.43 ton of air/ton of organic matter

For 2015 total waste generate is = 781.79 tons/day

Total air required for the solid waste = 14407.20 ton of air /day

Revenue from the Compost

Total compostable waste = 382.58 tons/day

Assuming total compost = 50% of original volume

Total compost = 191.29 tons/day

Price of compost in Guwahati = Rs. 1 per kg

So, total revenue from compost = Rs. 191289.03

Dimension of the Windrow Composting

Volume required for composting = (total solid waste in kg/ Density) = 1563.58 m^3

Considering air circulation arrangement and taking windrow height = 2.7 m, Width = 3 m Upper and 6 m Lower

Length required for composting = (volume/ (height/2) × (upper width + lower width)) = 12.15 m

As composting takes minimum 2 months, at least 60 numbers of windrows are needed for the whole city.

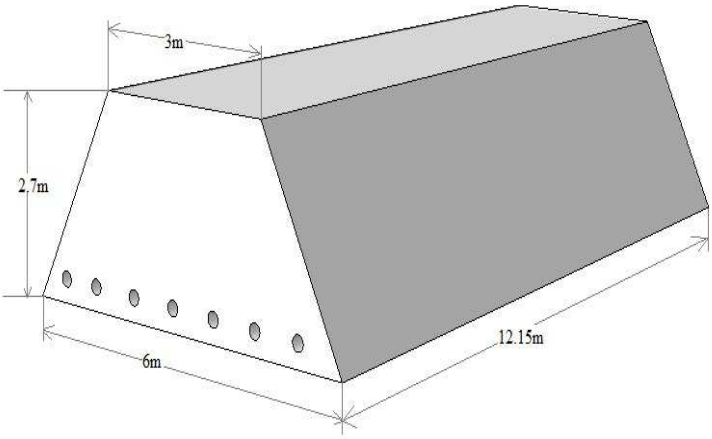

Figure 2: Composting Windrow

Landfill Design

The landfill design is adopted according the design given by manual on municipal solid waste management (2000), Ministry of urban development, Government of India.

Volume and Plan Area

Total waste goes to landfill in the year 2015 = 399.21×365= 145712.31 tons.

Total waste goes to landfill after 10 years in the year 2025= 559.87×365= 204354.01 tons.

So, the total waste generated for landfill for 10 years is = 0.5× (145712.307+204354.01) × 10= 1750331.58 tons.

Total volume of waste in 10 years (V_w) (on the assumption of 0.85 t/ m^3 density of waste),

$$V_w = T/0.85 = 2059213.63\ m^3.$$

Total volume of daily cover in n years (V_{dc}) (on the basis of 15 cm soil cover on top and sides for lift height of 1.5 to 2 m),

$$V_{dc} = 0.1 \times V_w\ (m^3) = 205921.36\ m^3.$$

Volume of Liner and Cover, Systems for a landfill of 20 m height,

$V_c = 0.125 \times V_w = 257401.70\ m^3$.

Volume likely to become available within 10 years due to settlement /biodegradation of waste,

$V_s = 0.1 \times V_w = 205921.36\ m^3$.

First Estimate of Landfill Volume $C_i = V_w + V_d + V_c - V_s = 2316615.33\ m^3$.

Let, length: width = 2:1, Landfill Height = 20 m

Primarily above ground level, partly below ground level.

Area required = 115830.77 m^2.

Plan Dimensions = 241 m × 482 m.

Additional 25 m land is acquired around the landfill to place infrastructure facilities.

Landfill section and plan

Landfill Section and Plan is designed on the basis of (a) 4:1 side slope for the above -ground portion of the landfill, (b) 2:1 side slope for the below-ground portion of the landfill, (c) Material balance for daily cover, liner and final cover material through excavation at site, (d) Extra space around the waste filling area for infrastructural facilities.

Landfill Phases

- Active life of landfill = 10 years.
- Duration of one phase = one year.
- Number of phases = 10. Each phase extends from base to final cover.
- One phase volume = landfill capacity/10= 2316615.333/10= 231661.5333.
- Plan area of phase = (Volume of one phase)/landfill height= 11583.08 m^2= 76 m × 152 m (approx.)
- Number of daily cells = 365
- Plan area of one cell /on the basis of 2.0 m lift of each cell= (Volume of one cell)/2.0= 13 m ×25 m.

Environmental Monitoring System

- Ground Water Monitoring Wells: Numbers = 4 (1 up gradient well; 3 wells along the sides in down gradient direction; all wells 20 m away from landfill)
- Lysimeters numbers = 2 × lysimeter under each phase. Total numbers = 20
- Gas Monitors: One portable gas monitors for landfill gas.
- Samplers: HDPE samplers (15 nos.) for (i) Groundwater samples, (ii) Leachate samples in vertical wells. Grab samplers for landfill gas (15 nos.) at (i) Passive vents, (ii) Gas wells
- Down-hole Monitors
- One multi parameter down-hole groundwater monitoring system

Liner System Design

Following the conditions given in Gulhati et al., (2012), a single composite liner system designed comprising the following layers below the waste:

- 0.35 m thick drainage layer with permeability $\geq 10^{-4}$ m/sec
- 1.50 mm thick HDPE geo-membrane
- 1 m thick clay layer with permeability $\leq 10^{-9}$ m/sec
- Sub soil

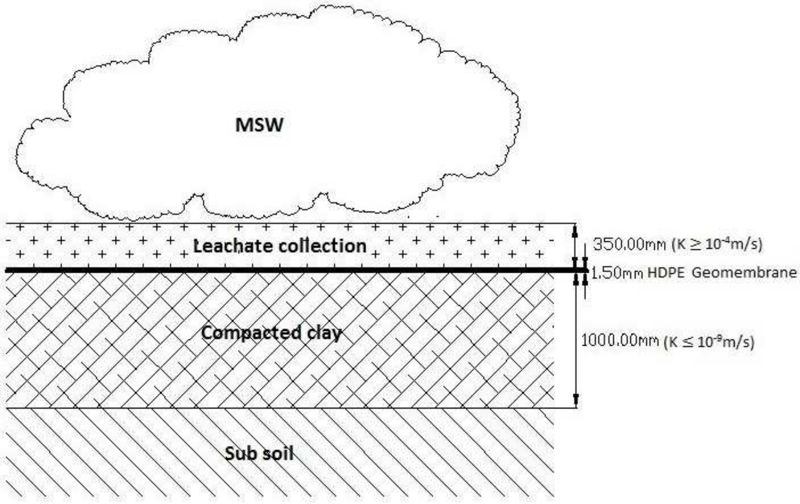

Figure 3: Liner System

Cover System Design

A cover system is also designed following the guidance given by Gulhati et al., (2012). The cover system comprises of following layers above waste:

- 0.3 m thick gas collection layer comprising of gravel (stone dust with no fines)
- 0.65 m thick clay layer having permeability $\leq 10^{-9}$ m/sec
- 1.50 mm thick HDPE geo-membrane. Geo membrane is used in this case to provide protection from seepage because Guwahati is an area with high rainfall
- 0.35 m thick drainage layer with permeability $\geq 10^{-4}$ m/sec
- 0.6 m top soil for vegetative growth.

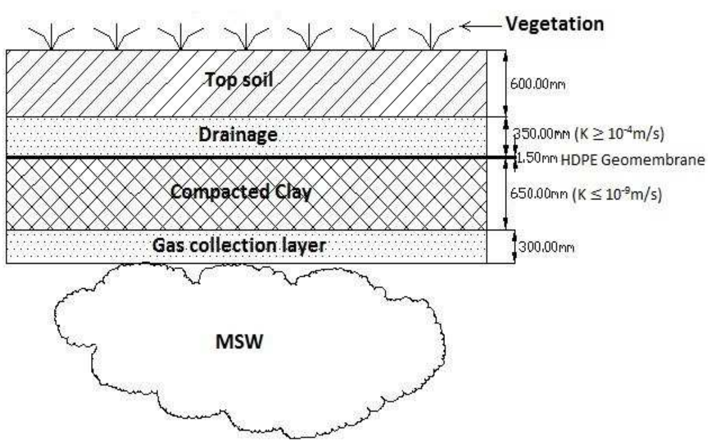

Figure 4: Cover System

CONCLUSIONS

For Guwahati city in the absence of an engineered sanitary landfill, the Boragaon land dump is working as an alternative. If composting is done then volume of waste going to the land dump will be reduced. Also, after composting segregation will be easy. For agricultural purpose of Guwahati, the compost will be a good choice. A combination of a composting plant and landfill in Boragaon will be an excellent idea for MSW treatment and disposal for Guwahati city. Apart from jobs it will surely create a healthy environment with a good amount of revenue and also less land will be required for the waste dumping which will be beneficial for future. As the compost plant and landfill will be near each other so transportation cost will be less and it will be economical. The work can be further continued by using some improved provisions for the compost plant like heat recovery from compost (Smith et al., 2014) and for the landfill like using superior liner, landfill gas collection system etc.

REFERENCES

1. Guidelines and Check-list for evaluation of MSW Landfills proposals with Information on existing landfills (2008), Central Pollution Control Board, Ministry of Environment & Forests**,** Parivesh Bhawan, East Arjun Nagar, Delhi-110032, August, 2008
2. Gulhati, S.K. and Datta, M. (2012). Geotechnical Engineering, Tata McGraw-Hill Education Private Limited, 7, West Patel Nagar, New Delhi 110008
3. Kaushik, K. and Bhattacharyya, A. (2012). Municipal Solid Waste Management and Energy Recovery from It – A Case Study Of Guwahati, Assam
4. Manual on municipal solid waste management (2000). Ministry of urban development, Government of India
5. Office of the Commissioner, Guwahati Municipal Corporation (2014). Panbazar :: Guwahati - 781 001
6. Siddiqui, A.A., Richards, D.J. and Powrie, W. (2012). Investigations into the landfill behavior of pretreated wastes, Waste Management 32 (2012) 1420–1426
7. Smith, M. and Aber, J. (2014), Heat Recovery from Compost: A guide to building an aerated static pile heat recovery composting facility, UNH cooperative Extension , June 2014
8. Varma, R. A., Status of Municipal Solid Waste Generation In Kerala And Their Characteristics, Executive Director, Suchitwa Mission